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receiving proper medical care at the expense of the United States Government.

In giving authority for the promulgation of regulations governing interstate travel of persons infected with contagious diseases, Congress made it possible for these regulations to be enforced by State or municipal health officers. If the State or municipal health officer should fail or refuse to enforce these regulations, the law declares that the President should enforce them.

In the act creating the Division of Venereal Diseases of the Public Health Service, Congress specified as one of the duties of the division 'to control and prevent the spread of venereal diseases in interstate, traffic." While it is possible from time to time for officers of the Division of Venereal Diseases to assist the States in preventing the interstate travel of venereally infected persons who are a menace, it is not intended or contemplated that either the Public Health Service or the State boards of health should police the boundary lines of all States. The provisions of State laws requiring that physicians should report names and addresses and other facts relating to venereally infected patients who refuse to continue treatment or who conduct themselves in a manner conducive to the spread of their infection, have been used effectively by many conscientious physicians who heretofore have been helpless when their patients ceased treatment with harmful results to such patients and danger to the community.

Many physicians have been successful in inducing patients to remain under treatment by calling attention to the provisions of these laws. It would be well if all physicians as well as local health officers would be apprised of the Federal Interstate Quarantine Regulations. Conscientious physicians could, by reference to these regulations, deter many persons who seek to escape the public health laws of their own State by traveling to a State where these laws are not so comprehensive, or where they are not as rigidly observed.

CARBON MONOXIDE POISONING IN CLOSED GARAGES.

The occurrence of fatalities as the result of carbon monoxide poisoning from the exhaust gas of automobile engines running in small, closed garages is a frequent item of news during the winter season; and the public, particularly automobile owners and garage workers, should be warned of the danger involved in running a gasoline engine in a small closed space, and advised to see that the garage is well ventilated by open doors or windows before permitting an engine to run for any considerable period of time. The principal toxic substance in the exhaust gas of gasoline engines is carbon monoxide, which quickly overcomes persons exposed to it above certain concentrations.

Some interesting experiments on this subject have recently been carried on in connection with a preliminary study of the problem of ventilation involved in the proposed vehicular tunnel under the Hudson River.[1] These experiments were made in especially prepared gassing chambers and relate principally to (1) the length of time it is safe to be exposed to various concentrations of carbon monoxide; (2) the comparative toxicity of pure carbon monoxide, illuminating gas, exhaust gas from gasoline and coal distillate, and (3) the amount of carbon monoxide given off in the exhaust of automobile engines. Human beings, horses, and dogs were used as experimental subjects.

As regards the rate of absorption of carbon monoxide into the blood, the authors state as follows:

"The body of an adult man of average weight contains enough hemoglobin to hold about 600 c. c. of oxygen. If completely saturated, it would hold the same amount of carbon monoxide, one molecule of carbon monoxide replacing one molecule of oxygen in the blood. The absorption of 6 c. c. of carbon monoxide from the lungs produces, then, 1 per cent of saturation and abolishes 1 per cent of the oxygen capacity.

"The unit in which various concentrations of carbon monoxide are commonly measured and expressed for purposes of ventilation is one 'part,' or a certain number of 'parts,' of this gas mixed with 10,000 times as much air. A part is a hundredth of 1 per cent of an atmosphere. A man at rest breathes about 8,000 c. c. of air per minute, of which about 6,000 c. c. reach his lungs, or 60 liters in 10 minutes. Let us suppose that this air contains one part of carbon monoxide, or 6 c. c. in 60 liters, and that all of this 6 c. c. is absorbed. The blood would then become saturated at the rate of 1 per cent every 10 minutes per 'part' of carbon monoxide in the air. Evidently the duration of exposure is a limiting factor in the amount absorbed, for one can not absorb more than one inhales.

"It appears that when a man begins breathing any low concentration of carbon monoxide mixed with air, absorption at very nearly this rate does occur, but only at first. Then the rate becomes slower. Even if the exposure is prolonged, carbon monoxide merely displaces oxygen from the blood up to a point of equilibrium depending upon the relative amounts or mass actions, of carbon monoxide and oxygen in the air breathed and the intensity of the affinities of the two gases for hemoglobin. If thereafter the pressure of oxygen is high enough and that of the carbon monoxide is low, or absent as in pure air, oxygen can likewise displace carbon monoxide and thus completely restore the oxygen-carrying power of the hemoglobin. The blood is neither directly changed nor injured by the process.

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[1] Physiological Effects of Automobile Exhaust Gas and Standards of Ventilation for Brief Exposures. Yandell Henderson, Howard W. Haggard, Merwyn C. Teague, Alexander L. Prince, and Ruth M. Wunderlich. Jour. Ind. Hyg., July, 1921, pp. 79-92, and August, 1921, pp. 137-146.

"Hemoglobin attracts carbon monoxide about 300 times as strongly as it does oxygen. Thus, if To_2 and Tco are the pressures of oxygen and carbon monoxide, and Hbo_2 and Hbco the amounts of oxyhemoglobin and carbon monoxide hemoglobin in the blood, the relations are expressed by the formula:

$$\frac{To_2}{Tco \times 300} = \frac{Hbo_2}{Hbco}, \text{ or}$$

$$\text{percentage } Hbco = \frac{Tco \times 300}{To_2 + (Tco \times 300)};$$

or, more specifically, if there are 1,500 parts of oxygen and 2 of carbon monoxide, the formula works out to:

$$\frac{2 \times 300}{1500 + (2 \times 300)} = 28.5 \text{ per cent}$$

saturation with carbon monoxide.

"The air in the lungs contains about 1,500 parts of oxygen in 10,000. (It is actually somewhat less than 15 per cent of oxygen. The affinity of hemoglobin for carbon monoxide may also be less, or more, than 300. We are here using round numbers merely to illustrate the principle without attempting mathematical precision.) We may calculate the blood equilibrium for any concentration of carbon monoxide in the air, and from such data we may obtain the carbon monoxide dissociation curve of the blood. This curve indicates that, if the air containing two parts of carbon monoxide in 10,000 is breathed for a time long enough to attain equilibrium, the blood should become about 28 per cent saturated; with four parts, 44 per cent; with six parts, 54 per cent; and so on. In the curve it is to be seen that, for instance, the equilibrium value for 10 parts of carbon monoxide in 10,000 of air is 66.6 per cent saturation, which is a sufficient degree of saturation to render a man unconscious and totally helpless. If continued, the asphyxia might lead to serious permanent injury or even death.

"The question of greatest practical importance is: How long a time would be required to attain this on any other definite percentage of saturation? In other words, what is the physiological law defining the rate of absorption of carbon monoxide into the blood? From the simple calculation, given previously, regarding the oxygen capacity of the body and the volume of air drawn into the lungs, it appears that a man breathing 10 parts of carbon monoxide would inhale enough of the gas to become 66.6 per cent saturated in 66.6 minutes. But, as already indicated, the more carbon monoxide the blood contains the greater becomes the force with which this gas tends to diffuse out again into the air. The more nearly this tendency equals and counterbalances the pressure of gaseous carbon monoxide in the lungs the slower the absorption of more carbon monoxide becomes. Thus, to attain a condition of complete blood equilibrium many hours would be actually required; indeed, the time is indeterminate. Doubtless other factors also play a part in retarding and stopping absorption.

"It appears to us, however, that *a definite quantity for determination would be the time required for attainment of a percentage saturation of one-half the equilibrium values.* Thus, in an atmosphere containing two parts of carbon monoxide, for which the blood equilibrium is about 28 per cent, how long a time would be required for the blood to become 14 per cent saturated? How long with four parts and an equilibrium value of 44 to attain 22 per cent saturation; or with six parts and an equilibrium of 54, to reach 27 per cent? The answer to this question is the principal practical contribution to knowledge which we have to make—namely, that *the time for attainment of half equilibrium for persons sitting at rest and breathing concentrations of carbon monoxide up to seven parts is never considerably less than one hour.* This fact is, we believe, of fundamental importance for ventilation engineering."

The following are the principal conclusions reached by the experimenters:

"When the time [of exposure] in hours multiplied by the concentration of carbon monoxide in parts per 10,000 of air equals 3, there is no perceptible physiological effect; when it equals 6, there is a just perceptible effect; when it equals 9, headache and nausea are induced; when it equals 15 or more, the conditions are dangerous to life.[1]

"If the volume of breathing is increased by exercise (even by slow walking and correspondingly more physical work), the rate of absorption of carbon monoxide is increased proportionately.

"After return to fresh air, the elimination of carbon monoxide through the lungs proceeds at a rate of from 30 to 60 per cent reduction of the blood saturation per hour.

"In the exhaust gas from gasoline, carbon monoxide is the only considerable toxic constituent. In the exhaust gas from coal distillate (benzol, etc.) and illuminating gas there are present accessory toxic substances."

In testing the exhaust of an automobile engine for the total amount of gas discharged per minute and the percentage of carbon monoxide it contained, a special building was erected with a cubic capacity approximately that of a section of the proposed vehicular tunnel which would contain one car under active traffic conditions. A small automobile, rated at 23 horsepower, was used. The power was employed in part to turn large paddle wheels which mixed the air in the chamber. Practically uniform concentrations of exhaust gas were found simultaneously in all parts of the chamber. It was found that the engine discharged a total of approximately 25 cubic feet of exhaust gas per minute; and samples of the exhaust gas unmixed with air gave from 5.5 to 6.8 per cent of carbon monoxide, an average of about 6 per cent, from which it appeared that approximately 1.5 cubic feet of carbon monoxide were produced by the car per minute.

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[1] EDITORIAL NOTE.—This statement is obviously restricted to certain limits as regards both time of exposure and concentration of CO. For example, exposure for a number of years to relatively pure air containing a trace of CO would give factors the product of which would indicate dangerous conditions according to the above formula.

If, then, a car while "warming up" should give off 1 cubic foot of carbon monoxide per minute in a closed room 10 by 10 by 20 feet, the atmosphere would reach the dangerous concentration of 15 parts in 10,000 in three minutes.

REPORT OF A HUMAN PLAGUE CASE IN SAN BENITO COUNTY, CALIF.

By W. T. Harrison, Passed Assistant Surgeon, United States Public Health Service.

The patient in the case here reported (R. S.) was a white schoolboy eight years of age, residing in the Bitterwater Valley, San Benito County, Calif. He became sick on the afternoon of June 8, 1921, and came home from school with fever, headache, malaise, and vomiting. There were severe pain and swelling in the right axillary region. He was taken to Hollister on June 10, at 2.30 p. m., and was seen by Dr. O'Bannon, who made a provisional diagnosis of plague.

On June 11, at 5 a. m., his temperature was 104.5° F. There were swelling and induration of entire right shoulder, great tenderness, mild delirium, and great prostration. On the lower border of the right scapula were two spots slightly inflamed which appeared to be insect bites. One drop of serum was withdrawn from edematous shoulder and inoculated on agar slants. At 1 p. m. on June 11, 90 c. c. of Pasteur plague serum was administered, 10 c. c. intravenously and 80 c. c. subcutaneously; on June 12, at 2 a. m., 60 c. c., subcutaneously; at 8 a. m., 40 c. c.; and on June 13, at 8 p. m., 40 c. c.

On the morning of June 15 the temperature was normal and the induration of the shoulder was rapidly subsiding.

On June 17 there was a severe serum rash, which continued for three days, with an elevation of temperature to 104° F. The temperature subsided June 20, and the induration of the shoulder disappeared.

Cultures from the serum withdrawn on June 11 were entirely negative. On June 14, after considerable induration had disappeared, additional cultures were made from an enlarged lymphatic gland, which